Electric Hauling of Boats

Notice of the Tests relating to Proportional Adhesion Tractors

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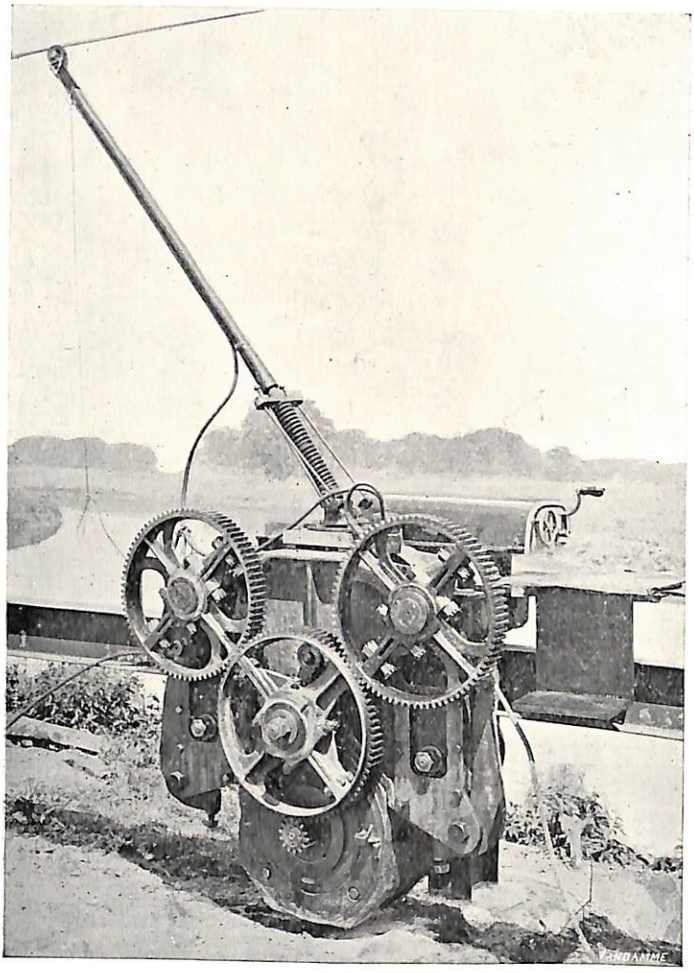

Fig. 1. — Proportional adhesion tractor.
(45 HP
Carter removed)

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It was stated in the report on the subject of American methods of electrical hauling, presented by Messrs St. John Clarke and Leon Gerard to the Navigation Congress held at Milan in 1905, that the obtaining of a proportional adhesion tractor gave the means for reducing greatly the first cost and the operating expenses of the system of mechanical traction.

Further and more extended tests have confirmed this view and demonstrated the perfect automatic action of the arrangement for adhesion.

The object of the present article is to give the details of the electro-technical tests by means of which was determined the mean efficiency of the new hauling machines, built, in the shops of the General Electric Company of Schenectady (United States), for the International Towing and Power Company of New-York.

Description

The electric tractor shown in figure 1, from which the carter, which covers the gearing, has been removed, is composed of a motor of the well known narrow gauge type of mine and railway motors of the General Electric Company, bearing the mark G. E. 61, A 1, of 45 normal HP when running at 500 revolutions continuous current at 550 volts.

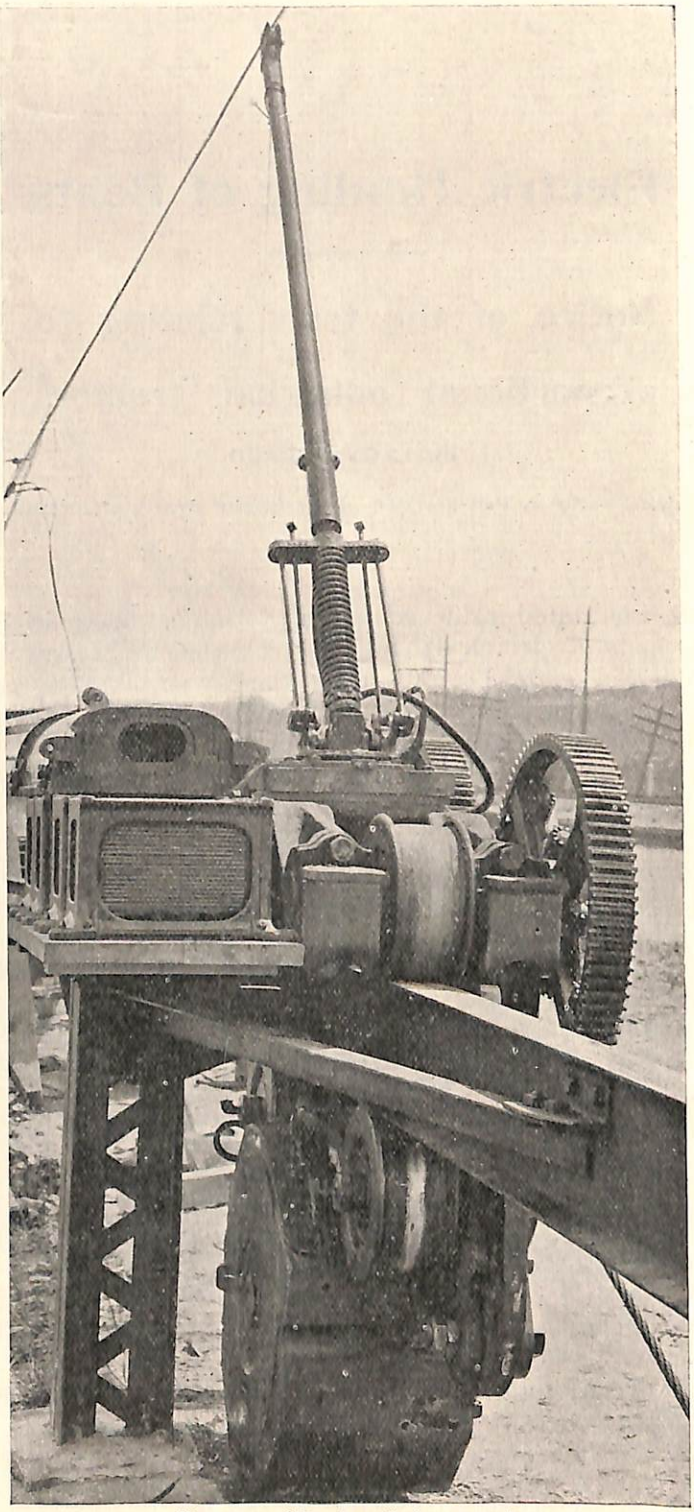


Fig. 2. — Side view. Carter removed.

The motor runs under the track which is made of a small laterally supported I beam 250 millimetres (10") high.

The end view of the tractor (fig. 2) shows the position of one of the two upper running rollers and of one of the two lower pressure rollers.

The characteristic feature of this tractor is first, its ability to give a pull at the hook equal to and even greater than the dead weight of the machine, and then to develope a reaction of friction, due to the pressures which cause adhesion, only when there is a pull at the hook, which reaction is proportional to the effort called forth by hauling.

It follows from these facts that the apparatus can run very fast when it is light with but a small expenditure of current, and that its electrical efficiency is very high under all sorts of loads.

This important result is obtained by means of the following described mechanical arrangements.

The schematic figure 3 is an elevation of the tractor. The gear wheels are shown by the dotted circles. The driving pinion works on a satellite wheel which plays the part of an endless chain, which drives the two gear wheels whitch turn the carrier rollers. The ratio of the number of teeth is 1 to 5.78 (14 to 80).

When running light, the whole system rests on the upper carrying rollers, and the resulting frictions which exist are due to the weight of the machine (2,920 kilogrammes) and to the friction of the set of gears.

Diagram 5, which relates to running light, shows that the apparatus can make a speed of 15 kilometres (9.31 miles) per hour, taking from the line only 7.16 kw.

At this gait, the compression rollers are not brought into play; a slight contact is made between them and the lower flange of the beam by means of the adjustable springs shown on the right and left of figure 3.

These springs are attached to the short arm of a forged steel lever, to the long arm of which the tow-line is made fast. If the machine move to the left, the tow-line is fastened to the right; if it run to the right, the lever on the left is used.

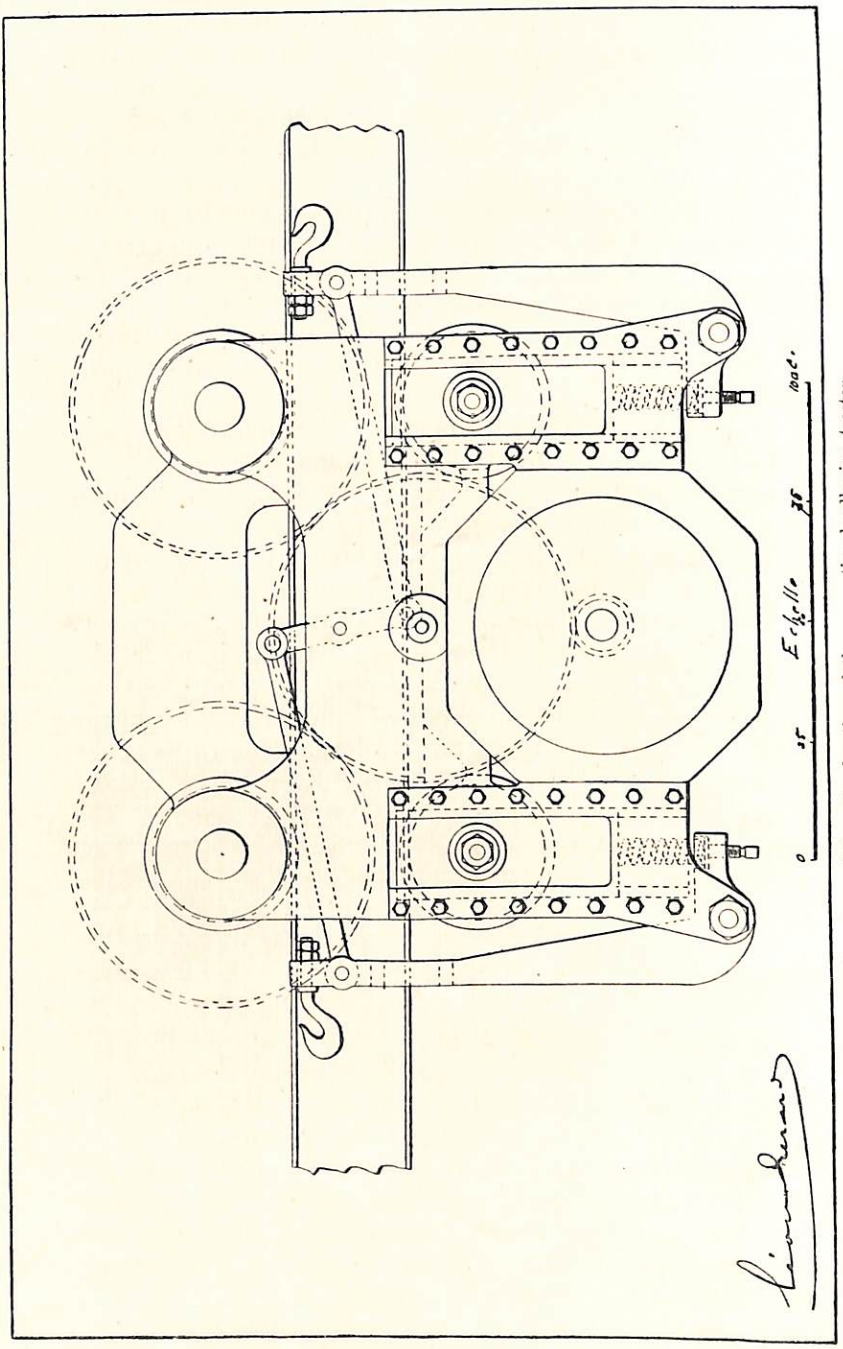


Fig. 3. — Schematic elevation of the proportional adhesion tractor.

The two levers are made to move together by means of three articulated bars shown by dotted lines on figure 3; the play of the parts can be regulated, like the rods of a railway brake, by screw threads at the ends, on which are fitted sleeve nuts. This mechanism for regulation is not given on the figure. It follows from the working of these parts that, if one of the long lever arms is pulled by the tow-line, the short arms of the two levers are raised

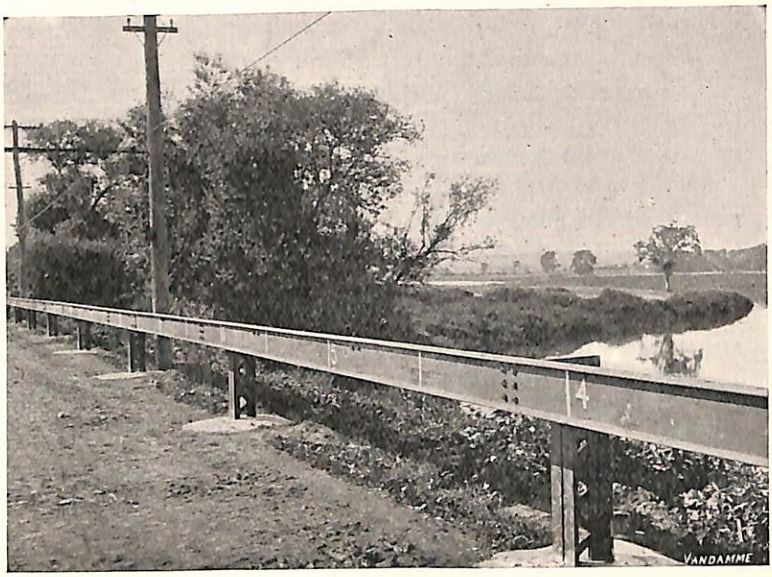


Fig. 4. — 25 centimetre (10 in) track. Weight per running metre, including supports, 60 kg (38 lbs per running foot).

and press the springs home, and the beam which forms the track is pinched between the rollers on top and the pressure rollers which are guided by the faced vertical slides. These slides are seen in figures 1 and 3.

The pressure exerted by the rollers is from five-and-a-half to seven times the pull of the tow-line. This pressure is strictly proportional to the pull. It only exists when there is a pull and concurrently with this pull. The pressure being proportional can be regulated

according to the state of the track, its dampness or smoothness, by coupling the tow-line and the hook to one of the holes placed more or less far up on the traction levers.

This arrangement allowed when at work, as is seen by the diagram (fig. 8) the development, without slipping, of pulls at the hook of 2,860 kilogrammes (= 6,300 lbs) when starting, and the maintenance of speeds of 5 to 7 kilometres (= 3.10 to 4.35 miles) per hour with pulls at the hook of 900 to 1,600 kilogrammes (= 2,000 to 3,500 lbs) with an electromechanical efficiency of 73 to 84 per-cent, the mean being 81 per-cent.

The details of the characteristic curves taken during the tests and the efficiency of the machine at various speeds will be considered further on.

The track used for the tests is shown in figure 4. By reason of the special requirements of this part of the Erie Canal (U. S.), the track is placed exceptionally on the outer side of the towpath.

As a rule, the track is placed at the edge of the water surface or along the quays, on the inside edge of the towpath or on the side slopes or again on the coping of the quay walls.

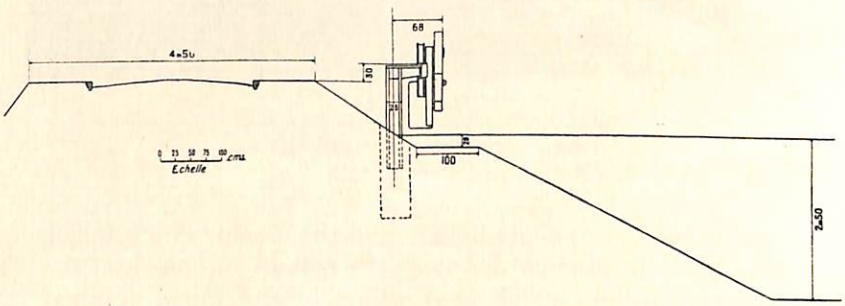


Fig. 5. — Section of electric tractor track laid on the bank.

The sketch (fig. 5) shows the arrangement for the open canal. Figure 6 shows the ordinary position in a narrow tunnel and makes clear how the reduction of the dimen-

sions of the electric apparatus facilitates adapting electric traction to existing tunnels.

In this connection, it is useless to dwell upon the fact, that mechanical traction is a necessity in canal tunnels. Hauling by animals is very slow and exceedingly troublesome and keeps up in them deplorable hygienic conditions.

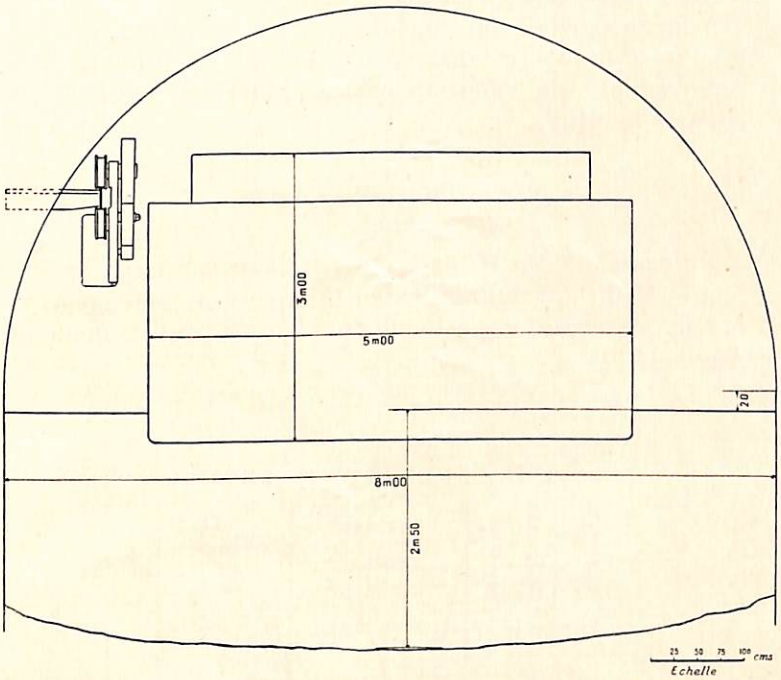


Fig. 6. — Tunnel section of canal with electric track and proportional adhesion tractor.

The existence of the banquette required for the movement of animals reduces greatly the useful section of the navigable highway.

The use of steam chain-haulers makes the operations less slow, but the vitiation of the air in the tunnels by the smoke of the engines is so great, that the intervals between the trains of boats must often be of several hours duration.

The breaking of chains or cables inside the tunnels causes long hunts for the ends and troublesome repairs, involving great disturbances of the traffic.

Electric hauling in tunnels does away with the banquettes, allows the use by higher practical commercial speeds, lights the roadway on which the operating conditions are as healthy as possible. Finally this system takes up but an exceedingly small part of the disposable section of the navigable highway.

A large part of the impediments to operating, caused by the ordinary conditions of hauling in tunnels, are removed by the adoption of the American methods of electric hauling.

Characteristic Curves

Figures 7, 8, 9, 10 and 11 are diagrams taken by the test-staff of the General Electric Company, at Schenectady, during a series of experiments of electric hauling made in August 1905.

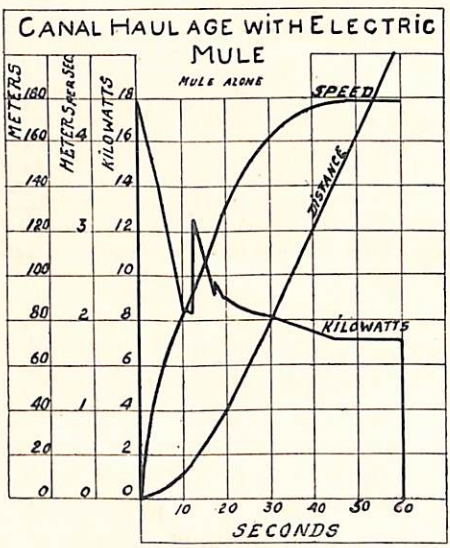


Fig. 7. — Diagram relating to tractor running light.

Figure 7 shows the diagram for starting and for normal movement when the machine is running light. The contact points of the controller are taken successi-

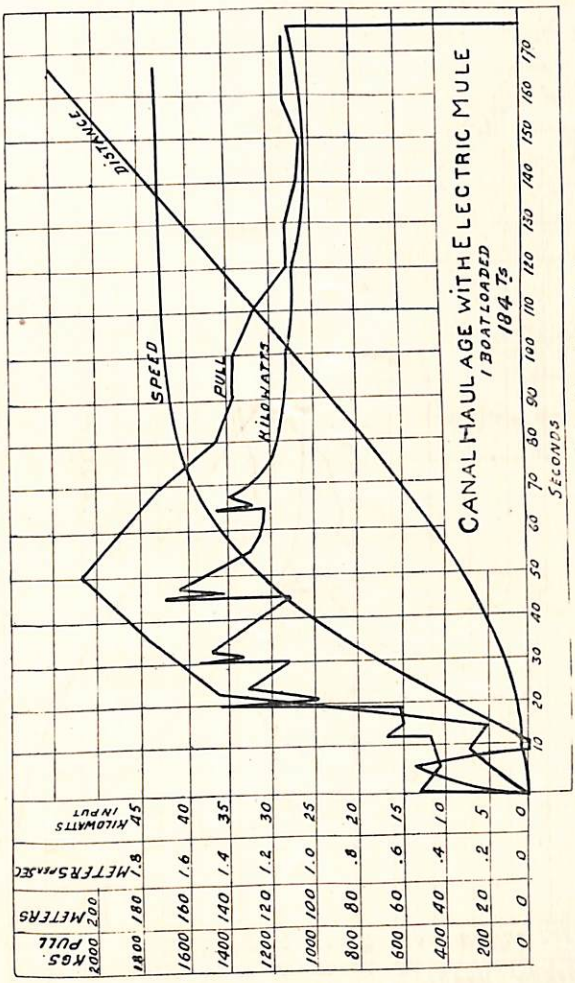


Fig. 8. — Diagram of start and traction of one boat.

vely : the second after five seconds, passing suddenly to the 4th at the 11th second and to the 6th at the 22d. Full speed is obtained at the 40th second. The regimen obtained corresponds to a speed of 15.1 kilometres

(= 9.38 miles) per hour with a current consumption of 7.16 kilowatts.

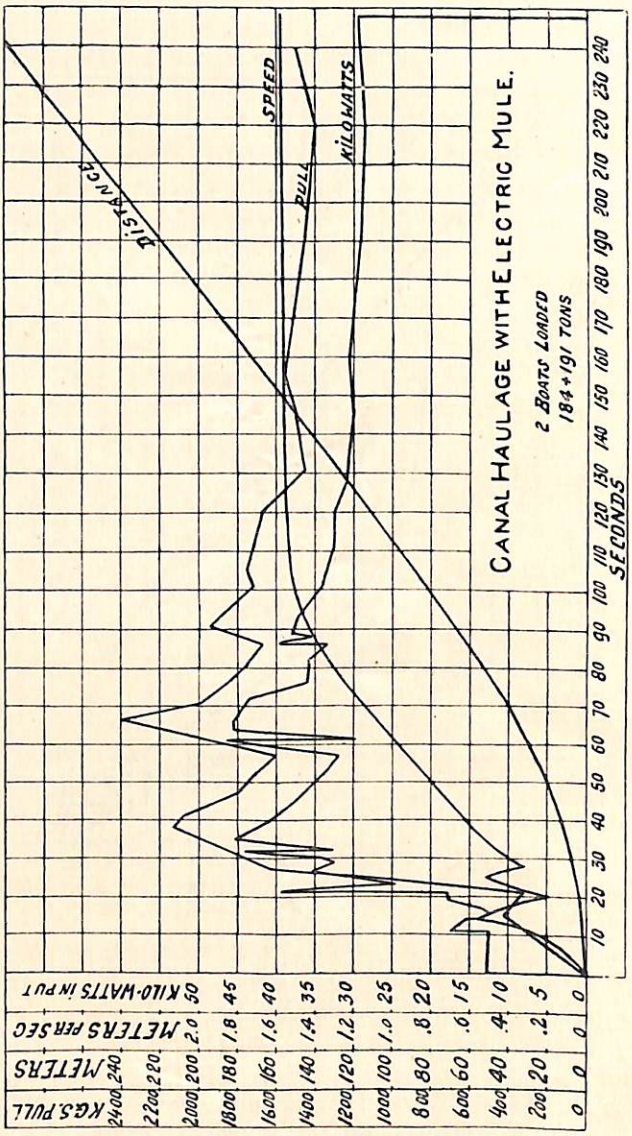


Fig. 9. — Diagram of start and traction of two loaded boats.

All the following tests were made against the current in the canal, the water having a velocity of 0.134 m. (= 0.44 ft) per second.

The second diagram relates to the traction of a boat of 248 tons, of which 184 tons was paying freight. The regular speed was obtained in 120 seconds; the 6th plot of the controller was reached at the 65th second.

The curve of recorded velocities is interesting to notice: 12 seconds, were required to obtain the tension on the towline and after that the speed increased regularly.

The strain at the hook increased, without slipping, regularly up to 2,080 kilogrammes (= 4,580 lbs) at the 5th contact of the controller (50th second).

The minimum efficiency during this test, at a speed of 6,000 metres (= 3.73 miles) per hour, was 68 %. The mean strain at the hook for this kind of boat was 1,085 kilogrammes (2,387 lbs) between the 120th and 174th seconds ; the speed in regard to the bank was 1.685 m. (= 5.527 ft) per second and the real speed on the water was 1.82 m. (= 5.97 ft) ; the mean useful work was 1,964 kilogrammetres (= 1,320 foot pounds), the work called for at the line was 26.5 kilowatts and the net efficiency was 72.7 per-cent.

The diagram (fig. 9) refers to the towing of two boats, of which one carried 184 tons and the other 191.

Full speed was obtained at the 140th second.

The form of the speed curve is the same as in the preceding diagram. The tow-line, longer than in the preceding test (50 metres), required 20 seconds to be drawn taut and the recorder marked two jerks of the line. At the 30th second the speed increased regularly and pulls of 2,100 and 2,420 kilogrammes (= 4,620 and 5,325 lbs) were recorded with no slipping.

The mean pull on the hook between the 146th and the 240th seconds was 1,480 kilogrammes (= 3,256 lbs), the apparent speed was 1.56 m. per second, the true speed was 1.69 m., the effective work accomplished was 2,500 kilogrammetres (= 1,675 ft. lbs.), the mean work taken from the line was 29.40 kilowatts, the net efficiency 83.5 %.

The diagram (fig. 10) gives the details of hauling a train of four boads loaded with 184, 191, 127 and 77 tons respectively.

The weight of tow hauled was 839 tons of which 579 tons were live weight. The length of the tow-line was 60 metres.

The speed curve shows three jerks of the line, diminishing successively in amplitude.

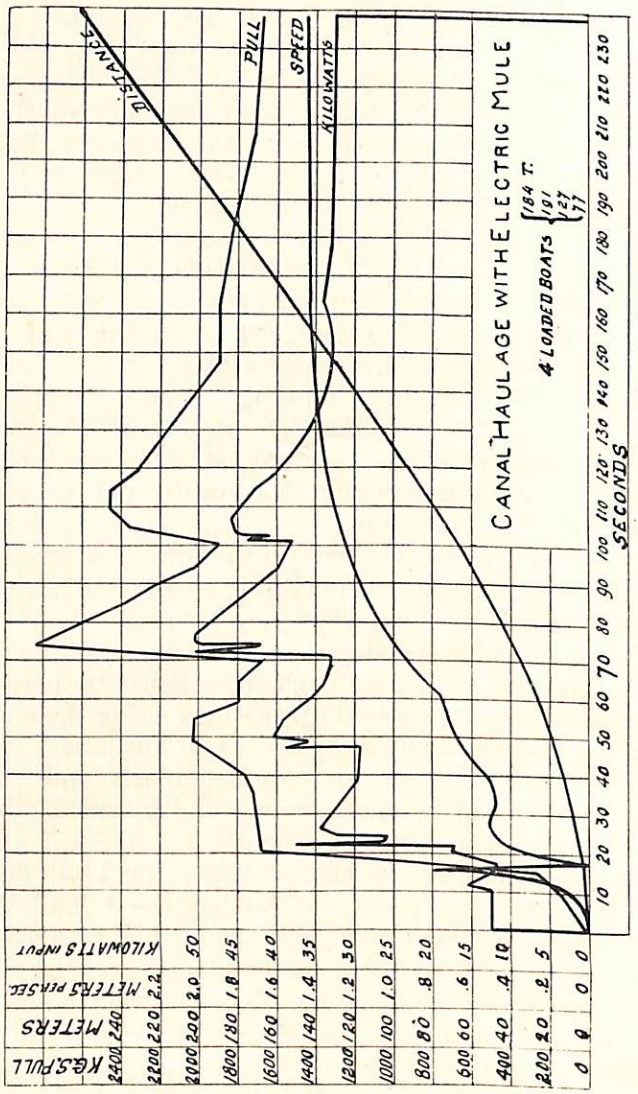


Fig. 10. — Diagram of start and traction of train of four loaded boats.

The six phases of successive contact with the controller plots are marked by six points on the diagram. The pull on the hook reached 2,860 kilogrammes at the

70th second, and the start ends at the 150th second, without slipping and without any jerk other than those caused by the elasticity of the tow-line.

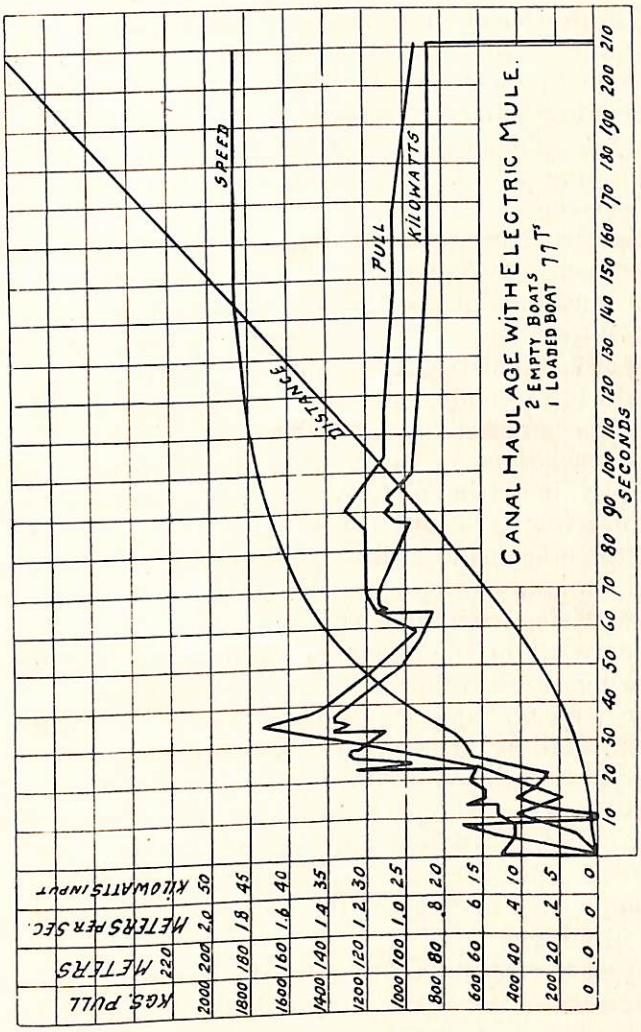


Fig. 11. — Diagram of start and traction of train of two empty boats and one boat with 77 tons load.

It is true that the recorded getting under way is abnormal and it cannot be expected that, in practice, a speed of 5.3 km. can be attained with a tow of 4 boats in 140 seconds.

The experiment was tried only to determine the power of adhesion proportional to the pull at the hook. It was thoroughly successful.

The part of diagram 10 corresponding to the establishment of the normal regimen gives an apparent speed of 1.44 m. per second (5,200 metres per hour), and an actual speed on the water of 1.5 of m., with a mean pull of 1,810 kilogrammes at the hook, or a useful work of 2,840 kilogrammetres (= 1,900 ft. lbs), and a consumption at the line of 33.1 kilowatts, or a net efficiency of 81.5 per-cent.

Diagram 11 relates to hauling a train of three lightly loaded boats : two empty barges weighing 65 tons each, and a third boat of 77 tons live load and 65 tons dead ; in all, 272 tons hauled, 77 tons being live load. A regular speed of 7,200 metres per hour was reached. The start, made in 146 seconds, shows the same phenomena recorded on the speed curve during the first 20 seconds.

The variations in the pull at the hook are smaller, naturally, in getting under way than they are in the quick start of a tow of heavily loaded boats.

On the other hand, it is more difficult to record a steady speed while in motion by reason of the momentary resistances arising from the position of the rudder.

The result of the readings of diagram 9 gives the following mean values : speed as compared with the water 1.85 m., apparent speed as seen from the bank 1.72 m., pull at the hook 1,000 kilogrammes.

Average work required from the line 21.8 kilowatts.

Net efficiency 83.5 per-cent. This in an average figure. With a light load and high speed, the machine gave readings which correspond to an efficiency of 86 per-cent.

The general average of the net efficiencies is greater than 81 per-cent.

The following table sums up the results of the tests obtained from the preceding graphic sketches :

Synoptical table of tests relating to the proportional adhesion tractor

Number of boats	Total weight hauled	Live load	Speed in metres per second		Mean pulls kilog.	Useful work in K. G. M.	Work in kw. taken from the line	Efficiency o/o
			apparent	real				
1	248	184	1.68	1.81	1085	1964	26.50	72.7
2	505	375	1.56	1.69	1480	2500	29.48	83.5
3	272	77	1.72	1.85	1000	1854	21.80	83.5
4	839	579	1.44	1.57	1810	2840	33.10	84.5
General average of efficiencies 81 °/o								

The tests were made with square-bow boats :

Having a mean length of. . . . . 29.56 metres
» width at the midship beam of . 5.33 »
» draught of water light of . . 0.406 »
» » when fully loaded of . 1.625 »

The dead weight of the boats is 65 tons.

The cross-section of the Erie Canal at the site of the trials shows a width at the surface of the water of 17 metres, the batter of the quays is about 10 on 1, the depth of the water is from 2.40 m. to 2.80 m.

It is interesting to note the advance made, in the matter of mechanical performance, by the electric methods of hauling.

The latter, from the beginning, were superior in mechanical efficiency to the screw tugs, of which the efficiency oscillated between 28 and 32 per-cent (1).

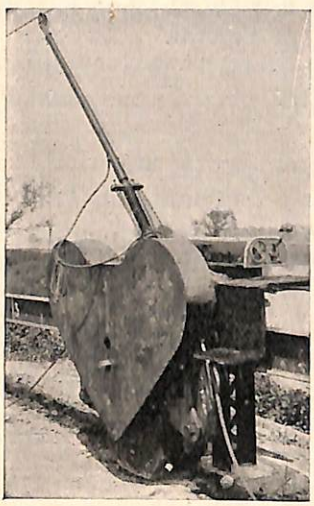
The following table gives a general view of the improvements made since Gaillot's first tricycles and the road quadricycles used on the Deule canal in France and the Charleroi canal in Belgium, passing then through the tractors on rails, tested successively in Belgium, in France at Douai, then later on the Teltow-Kanal in Germany :

(1) See *Bulletin de la Société belge d'Electriciens*, vol. XVIII, 1901, pp. 30 and 31. Léon Gerard, « Notes et expériences sur la traction électrique ». Report to the VIIIth Navigation Congress, Paris 1900.

Comparative table of efficiency and power of electric tractors for boats

NAMES OF THE APPARATUS	CANALS	DATE OF MEASURES	POWER IN KW.	MEAN EFFICIENCY
Gaillot tricycle on the bank.	Burgundy Canal	1895	6	0.40
Siemens tractor on rack single rail	Finow Canal	1898	12	0.58
Gaillot tricycle on the bank.	Deule Canal	1900	10	0.43
Gerard quadricycle on the bank	Charleroi Canal	1899	7	0.50
Gerard tractor on two smooth rails. .	Charleroi Canal	1902	12	0.65
French tractor on two smooth rails .	Deule and Scarpe	1904	20	0.675
Siemens tractor on two smooth rails. .	Teltow Canal	1904	15	0 65
Wood tractor on mono-rail	Erie Canal	1904	70	0.64
Proportional adhesion tractor	Erie Canal	1905	35	0 81

In a word, it is seen that traction machines have acquired in ten years an efficiency twice as great as that which they possessed at first, and that the efficiency of the new American method is equal to that of the best electric tramway equipment.



These machines reduce the organ of traction to the lowest limit of simplicity and compactness.

Marked advances have been made in the matters of weight, first cost, plant and track, and now there are at the disposal of the operating departments of navigable highways electric traction tools of great mechanical perfection and of equally great economic value.

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